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INTERIOR POSITION ON THE EROS DATA CENTER

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EROS Data Center

U. S. Geological Survey

Sioux Falls, South Dakota 57198

Interior Position on the EROS Data Center

I. Background

The operative statements in NOAA's recent transition plan for the civil satellite land remote sensing program related to the Department of the Interior's EROS Data Center located in Sioux Falls, South Dakota, are (as extracted from the plan):

> "The only functions at the EROS Data Center within NOAA's new management responsibility for the U.S. civil operational land remote sensing satellite program are the national archiving of Landsat data, and the servicing of users who draw upon this archive. Two-thirds of the functions performed at EDC, such as the archiving of Interior's aircraft data and serving users who draw upon this archive, as well as research related to Landsat applications and the conduct of training programs in use of Landsat data, primarily service Interior in the performance of its missions. Interior and Commerce have agreed that it is in the best interests of the programs of both agencies that the national Landsat archiving and retrospective user services functions be co-located with the preprocessing facility for the Landsat program at the Goddard Space Flight Center....The transfer of these functions to NOAA will occur in FY 1984 when operational use of Landsat D MSS data has begun and management responsibility has been transferred to NOAA. These transfers will result in the loss of revenues to Interior from the sale of Landsat standard data products--currently $2.7 million. Future revenues will be collected by NOAA, placed in a revolving fund, and used to offset the costs of the System. No civil service positions will be transferred to NOAA since EDC will need to retain these positions to manage its continuing critical activities for the Department of the Interior."

II. Summary

Beginning in FY 1984, as NOAA assumes responsibility for Landsat data processing and distribution, the mission of the EROS Data Center will be to serve as an Interior support facility providing data products,

training and technical assistance, applications research, and analytical services to Interior bureaus and offices. The EROS Data Center will be operated to satisfy Interior requirements as a user of remote sensing data.

EDC, as a centralized Interior support facility, will access the Landsat digital data stream from the NOAA data processing site at GSFC. The Data Center will use existing equipment and facilities to produce those unique data products required by Interior's bureaus and offices. EDC will continue to archive, maintain, and process Interior aerial photography, making copies available as required by Interior's bureaus and offices. EDC must also continue to make copies of the Interior aircraft data available to the general public via appropriate Freedom of Information regulations.

Research and development will continue at the Center in cooperation with other bureaus and offices of the Department specifically addressing the information needs of those bureaus and offices. Training, user assistance, and other forms of technology will, likewise, be directed at the bureaus of the Department. Analytical services will be provided to the bureaus and offices of Interior.

The EROS Data Center is the backbone of Interior's application of satellite land remote sensing data. The Center has had, and must continue to have, a key role in the development of Interior required

applications techniques; the transfer of land remote sensing technology to Interior users; the processing and distribution of Interior unique satellite data products; and the archiving, reproduction, and distribution of large quantities of Interior acquired aerial mapping photography.

III. Interior Use of Satellite Land Remote Sensing Data

The Department of the Interior is the Nation's principal conservation and resource management agency, responsible for the administration of over 500 million acres of Federal land, and employing almost 60,000 personnel with an annual budget of almost $5 billion.

It is estimated that roughly 700 full-time or near full-time man-years are being devoted to the application of satellite land remote sensing data within Interior. Total investment in Interior facilities and equipment employed in the use of this data approaches $50 million, with annual operating budgets of roughly $25 million. Between $350,000 and $400,000 in film and digital data products (at current prices) are purchased each year by Interior data users. Major locations of Interior analysis and use include Washington, Reston, Sioux Falls, Flagstaff, Denver, Anchorage, Fairbanks, Menlo Park, Ft. Collins, St. Petersburg, Tacoma, Gulfport, Rolla, and others.

Somewhat over one-half of these total resources are located or expended at the Interior central remote sensing center, the EROS Data Center in Sioux Falls, South Dakota.

Interior is currently making routine use of satellite remote sensing data in several major activity areas and anticipates continued growth in the diversity, and sophistication of applications as improved data from future planned systems becomes available. The following is a list of specific examples of Interior use of satellite land remote sensing data:

- o Mapping geologic structure for mineral and fuel exploration (GS, BLM).
- o Identification of geologic structures for hazard assessment (GS, BLM).
- o Surface water inventories (GS, BLM, F&W, WPR).
- o Wetland inventories to assess wildlife habitat (F&W).
- o Monitoring irrigated lands (BLM, WPR).
- o Route selection for utility corridors (BLM, BPA, WPR).
- o Regional environmental surveys for preparation of environmental impact statements (GS, BLM, WPR, F&W).
- o Regional wildland vegetation mapping and wildland habitat assessment (F&W).
- o Alaska Federal lands inventory and vegetative land cover mapping (including support of the Native Lands Act) (BLM, F&W, GS).
- o Source material for the National Land Use/Land Covering Mapping Program (GS).

- o Preparation of image maps of unmapped or poorly mapped regions of the Antarctica and other regions in support of national and international cooperative efforts (GS).

- o Flood and other natural disaster impact assessments (GS, BLM, WPR, F&W).
- o Map forest and rangeland fire scars and monitor rate of revegetation (BLM).
- o Monitor coastal shore line changes (GS, F&W).

In addition, the following is a list of "near-operational" applications of satellite data, i.e., applications that will achieve operational status with minor refinements in techniques or data characteristics and/or improvements in the reliability or timeliness of data delivery:

- o Identification and analysis of rock alteration areas and potentially mineralized zones.
- o Monitoring Alaskan sea ice conditions for off-shore operations and transportation route suitability.
- o Detection and monitoring of surface mining and mine reclamation activities.
- o Land use and land cover change detection and statistical analysis.
- o Monitoring long-range regional environmental changes resulting from cultural development or natural disasters.
- o Agricultural crop classification for irrigation water use determination.

- o Monitoring snow cover accumulation and melt in watersheds and hydroelectric catchments in order to contribute to predictive hydrologic models and runoff calculations.

- o Monitoring rangelands for drought and other forms of stress.
- o Site suitability evaluation and recreation resource inventory of national park lands.
- o Oil slick detection and monitoring.
- o Monitoring rangeland to cropland conversion.
- o Monitoring of desertification and drought assessment.
- o Geohydrologic analysis and ground water targeting methodologies.
- o Monitoring of forest defoliation and other stages of vegetation stress.
- o Assessment and monitoring of physical water quality and turbidity.
- o Shallow seas mapping in trust territories.

IV. Interior Resources Dedicated to the Use of Satellite Data

U.S. Geological Survey

- o Office of Earth Sciences Applications EROS Program activities at Reston, Virginia, the EROS Data Center in Sioux Falls, and Field Offices in Anchorage, Fairbanks, Mississippi, and Flagstaff. Approximately 450 man-years. The EROS Data Center is a $37 million facility for the centralized support of Interior's remote sensing data and applications needs including data handling, research and development, technology transfer, training, assistance, etc. The Anchorage Field Office houses over $600 thousand in analysis equipment and is staffed by 5 full-time scientists/engineers.

- o Geologic Division facilities at Denver and Flagstaff represent an investment of over $2.5 million with some 30 personnel involved.

- o National Mapping Division facilities at Reston, Denver, Menlo Park, and Rolla, with equipment valued at $1 million and some 15 personnel involved.
- o Water Resources Division activities at Reston, Sioux Falls, Tacoma, and numerous district offices with some 20 scientists/technicians involved in data use; 200 satellite data-relay stations are in operation.

Bureau of Land Management

- o Some 40 to 50 full-time scientists and technicians working in facilities in Denver, Washington, and district, State, and area offices. The largest activity is at the Denver Service Center which houses analysis equipment representing an investment of more than $2 million and operated by the Branch of Remote Sensing. 150 to 175 BLM resource managers receive dedicated training in the use of remote sensing data each year.

Water and Power Resources Services (Formerly the Bureau of Reclamation)

- o Some 20 scientists and technicians in Denver and the various regions of WPR including a $1 million analysis facility in Denver operated by the Remote Sensing and Engineering Section. 20-30 resource managers are being trained in the use of satellite remote sensing data each year.

U.S. Fish and Wildlife Serivce

- Activities at Ft. Collins, Colorado operated by the Western Energy and Land Use Team, Data Support Group, and at St. Petersburg by the National Wetland Inventory Program have roughly 25-30 personnel involved in the use of satellite remote sensing data. Between 75 and 100 professionals are receiving training each year.

National Park Service

- Approximately 20-30 personnel are involved in the analysis and application of satellite data to national park and park resource management at Denver and other locations within the U.S. The Denver operation has proposed the development and implementation of a $500 thousand image analysis system.

Bureau of Indian Affairs

- No dedicated facilities, but some 10 to 15 individuals involved in the use of remote sensing data throughout the U.S. Approximately 15-30 professionals are receiving training in the use of the data each year.

Bureau of Mines

- Approximately 6 full-time personnel involved in the use of data and using computer and digital display equipment valued at $1.5 million with plans for a dedicated digital processing system valued at $650,000. Some 10-20 professionals are receiving training each year.

Office of Surface Mining

- Approximately 5 full-time remote sensing specialists with 75-100 mine inspectors using remote sensed data on a routine basis. An additional 30-45 personnel are receiving training each year.

V. Questions and Answers on Role of The EROS Data Center

In order to further explain the role of the EROS Data Center before and after the transition, the following questions and answers are provided:

1. Question

Which ongoing EDC activities will continue after the transition and at what level? Quantify capabilities and level of resources required and compare them with current capability and resources.

Answer

Activities and resources being utilized at EDC can best be understood if logically grouped into the following categories:

A. Applications Research and Development

B. Training and Technical Assistance

C. Landsat Data Handling and Distribution

D. Aircraft Data Handling and Distribution

E. Fixed Facility Operations

Specific efforts now underway and to be continued through the transition time period can be summarized under these general

categories. The following table details resources against these categories. Appendix A is a narrative description of major activities underway and continuing after the transition at the EROS Data Center.

Table 1. Projected Resources (FY 82 $ in Millions)

	FY 81	FY 82	FY 83	FY 84
Expenses				
A. Applications Research and Development (Including Reston Program Office)	4.0 (73 MYE)	4.3 (73 MYE)	4.3 (73 MYE)	4.3 (73 MYE)
B. Training and Technical Assistance	0.9 (20 MYE)	1.0 (20 MYE)	1.0 (20 MYE)	1.0 (20 MYE)
C. Landsat Data Handling and Distribution (Including Data Processing, Archiving, Inquiry, Production, Order Handling, Accounting, and Data Distribution)	4.3 (113 MYE)	4.8 (113 MYE)	5.3 (124 MYE)	2.3[1]/ (54 MYE)
D. Aircraft Data Handling and Distribution (Including Data Archiving, Inquiry, Production, Order Handling, Accounting, and Data Distribution)	3.5 (118 MYE)	3.8 (118 MYE)	3.8 (118 MYE)	3.8 (118 MYE)
E. Fixed Facility Operations	4.3 (78 MYE)	4.5 (78 MYE)	4.5 (78 MYE)	4.5 (78 MYE)
	17.0 (402 MYE)	18.4 (402 MYE)	18.9 (413 MYE)	15.9 (343 MYE)
Reimbursables				
A. From Training Services and Cooperative Projects	1.2	1.2	1.2	1.3
B. From Landsat Product Sales	2.7	2.9	3.0	0.7
C. From Aircraft Product Sales	1.0	1.1	1.2	1.3
Net Appropriations Required	12.1	13.2	13.5	12.6

1/ For Landsat, production systems R&D is eliminated with Interior required R&D being continued; "pipeline" data processing is deleted; the Domsat interface with GSFC is continued for 5,000 to 10,000 scenes/year and EDIPS produces Interior required products; 80 percent of existing Landsat costs in archiving, data base management and information services are deleted; the Landsat working archives are reduced from 1.4 million to a few thousand frames; Landsat orders are reduced from 20,000 per year to less than 5,000 per year and Landsat data production decreases from 150,000 frames per year to 40,000 frames per year.

2. Question

What percentage of the total EDC applications R&D and training effort has been devoted to Interior needs and requirements over the past 2-3 years (as opposed to "outside" Interior support)? What reduction in this effort will occur after FY 83 when EDC becomes an Interior "only" Support Facility?

Answer

Over the last 2-3 years about 85-90 percent of EDC's applications R&D and training effort has been directly or indirectly related to DOI needs and information requirements. These R&D activities include: (a) operating, maintaining and making available to DOI personnel advanced computerized image analysis equipment and capabilities, (b) performing applications research to improve DOI capabilities, using remotely sensed data, to map wetlands, map geologic features, assess geologic hazards, monitor irrigated lands and map vegetation, and (c) making new advancements for DOI in image analysis technology, such as atmospheric correction, geometric correction, classification, enhancement, temporal data analysis, statistical analysis, ground data correlation, and multi-sensor data correlation and analysis. Technology transfer activities include training workshops and courses, day-to-day user assistance and cooperative demonstration projects. Most DOI bureaus and agencies have participated directly in these EDC activities. An example of an indirect-DOI activity is the cooperative project between the USGS and People's Republic of China on Landsat analysis of oil basins in China. In response to

official requests, some training and project work (about 10-15 percent) has been done with non-DOI organizations such as the U.S. Forest Service, U.S. Army Corps of Engineers and Mine Safety Health Administration.

Reductions in EDC's applications R&D and training efforts after FY 1983 are anticipated to be minimal as EDC transitions to a DOI support facility since: (a) training will shift from the fundamentals of data analysis and interpretation to more advanced topics of particular interest to DOI -- such as geobased information systems, use of Earth science models and sampling/inventory methodology, (b) demand by DOI bureau and offices for cooperative demonstration projects at EDC continues to increase for projects over larger geographic areas, with increased levels of complexity, which test the operational utility of remote sensing techniques, (c) improved sensor and data characteristics over the next decade will require new advancements in digital image processing and analysis technology and additional research to achieve successful, operational DOI applications, (d) scientific, technical and administrative support will be required by EDC for the fully operational Alaskan Field Office in Anchorage, Alaska, and (e) EDC will provide to DOI bureaus and offices unique image processing/analysis services such as "host" computer support to a DOI network of remote image processing stations.

3. Question

How and in what form will EDC and Interior obtain data products from the NOAA core system after the transition?

Answer

Stated Interior Interim Operational System Satellite remote sensing data needs are:

a. 5,000 to 10,000 MSS scenes per year and 500 to 1,000 TM scenes per year.

b. Data delivery within one week with 85 percent reliability.

c. For roughly 10 percent of the above data, delivery within 48 hours.

d. Unresampled digital data which will allow generation of a variety of unique and customized digital and film data products, including area selectability, digital mosaicking, data set merging, image enhancement, products of production analysis, etc.

To satisfy the above requirements, the EROS Data Center will interface with the NOAA core data processing facility at GSFC and produce Interior required custom-tailored data products. (Similar to the USDA primary user facility now located at Houston and supporting AgRISTARS and Foreign Agricultural Service requirements.)

The EDC will receive MSS and TM unresampled digital data via the existing communications satellite link (editing of data can be at GSFC or EDC). The existing EROS Digital Image Processing System (EDIPS) will be used to produce enhanced and custom processed Interior required CCT and film data products in the format and time frame required by Interior users.

As described in the Transition Plan, and as recommended by OMB, the NOAA core system should not be designed to produce, nor will it include the capability to produce, those enhanced or customized products uniquely required by user agencies such as Interior. The NOAA core system will produce "standard" products only, and user agencies such as Interior will budget for and operate those unique capabilities required by the Interior.

4. Question

Is funding for purchasing data from NOAA (or the private sector) in the Interior budget projections for FY 1984 on?

Answer

Interior bureaus and offices currently purchase some $350,000 to $400,000 of Landsat data (at today's prices) each year. In addition, Interior reimburses NASA for computer tapes (roughly $100,000 per year) and for Domsat link services (approximately $250,000 per year). These costs can be assumed to be continued into outyear budget projections. Costs over and above these are not currently included in outyear budget projections.

5. Question

Will Interior users pay for the cost of operating such a central user facility? What are they now paying?

Answer

Users (including Interior users) are now and will continue to reimburse the central facility (EDC) for identifiable and specific products and services provided. Users currently provide some one-third of the total funding required for Data Center operations. This user-provided funding percentage is projected to increase gradually over the coming years. However, a substantial amount of applications and technique research and development, along with core facility operations, are not identifiable to a specific benefiting Interior bureau or office. From a practical standpoint, these operations need to be funded from a single appropriations line item to provide continuity and assure that Interior makes full use of the large Federal investments in space hardware and operations.

6. Question

Will the civil service staff decrease after the transition?

Answer

Those operations associated with the archiving and public distribution of Landsat data that are being transferred to NOAA are almost totally contractor operated. All of the EDC organizational elements

such as User Services, Data Management, the Photo Laboratory, etc., have a single civil service technical manager and between 30 and 100 on-site support contractor personnel.

In addition, the data handling elements of EDC are responsible for both Landsat and aircraft data and all equipment and facilities will continue to be operated in support of aircraft data handling. The reduction in workload associated with Landsat data is projected to result in a decrease of 50 to 60 man-years in the contractor work force. The current EDC staff is 50 civil service and 352 on-site support contractors.

7. Question

Why do EDC "facility costs" remain fixed during the transition? What makes up these "fixed" facility costs?

Answer

Certain of the costs associated with the continued operation of EDC remain relatively fixed and will not change appreciably with moderate changes in the direct workload. This is particularly true since all of the equipment and space at the Center is used for shared spacecraft and aircraft data processing and aircraft data handling will continue after the transition. A summary of costs included in this category are (FY 81 costs):

Utilities	406.8
Building Lease/Purchase	802.8
Taxes	123.0
Buildings & Grounds Maintenance	985.4
Office Equip. Rental/Office Supplies	136.4
Computer Lease	934.2
Computer Maintenance	194.9
Center Management & Admin. Support	548.0
Security Services	131.5
	4,263.0

8. Question

What Landsat data handling activities will continue at the EROS Data Center following the transition?

Answer

At the time of this transition, the Data Center will physically archive approximately 1,750,000 frames of historical Landsat data; operate extensive systems for processing Landsat data and producing unique data products for DOI users; have available manual and computerized systems for DOI users to access the EDC held Landsat data; annually receive either on high density digital tape or via domestic communications satellite between 5,000 to 10,000 scenes of current Landsat data which is

needed by Interior users. In addition to the vast archive of historical and current Landsat data, satellite data from other programs (including the Heat Capacity Mapping Mission, Metsat, Mapsat, Seasat, Stereosat, the French Spot program, Japanese satellite program) will be available through the Center for Interior users thus providing a one-stop shop for a variety of satellite and aircraft remote sensing data.

Techniques for merging satellite remote sensing, geophysical, topographic and other forms of digital georeferenced data to improve interpretation results and to input predictive models have recently been developed. Geometric correction algorithms are available for processing data sets as geographically registered data. This capability will allow processing of data according to a variety of menus, resulting in a spatially registered set of images which can be provided on either magnetic or film media. Once the data is geometrically corrected, a library of enhancement algorithms can be applied to improve image quality, filter radiance values, or perform radiometric adjustments. Using these techniques a variety of input media can be corrected, reformatted, and enhanced to provide digital or film products specifically tailored to a DOI users particular needs. These products can then be used in the users' own environment, either by automatic or manual interpretation. To supplement this data integration, information in hard copy form such as topographic, soils and geologic maps can be converted to digital line graphs via EDC digitizing systems. This capability will be offered as a service to DOI users.

The user of remote sensing data will not be constrained to scene geographic limitations imposed by the system collecting the data. Rather, a geographic area can be defined of the area of interest. Where multiple scenes of data are involved, techniques for radiometrically feathering image border areas are being developed for production of high-quality digital or photographic mosaics.

Consistent with the implementation of improved systems for handling, processing, and analyzing (thematic information extraction) remote sensing data, the Data Center is developing optimized data/information packaging techniques for use with the most advanced means of getting the data/information to an end DOI user consistent with his particular needs. High and low density digital data can be transmitted via domestic communications satellite or land line if needed in a timely manner. Also, data compression techniques are being developed that will allow efficient, cost effective transfer of image data and extracted resource information to and from analysis systems located at the EROS Data Center. Thus many DOI users in the field equipped with the low cost Remote Image Processing System that is being developed by the Data Center can interact with the large, sophisticated host system and receive only the resource information they need.

9. Question

What data handling and information systems capability will the Center have to retain for Interior aircraft data?

Answer

3,361,000 frames of mapping and resource aerial photography acquired by agencies of the Department of Interior currently reside at the EROS Data Center. These photographs have been acquired by the USGS, BIA, BLM, WPRS and others in the discharge of their agency responsibilities. New photography is being acquired at a rate of approximately 200,000 frames per year. Federal agencies within and without the Department of Interior use reproductions of these photos, often eliminating the need to acquire new photographic coverage.

The public has traditionally had access to reproductions of the photography acquired by the USGS. The Freedom of Information Act now mandates public access to all of the aerial photography acquired by the Department. Increasing awareness of the availability of these images is coupled with an increasing demand for reproductions from the public and private sectors.

No other laboratories in any of the bureaus are adequately equipped and staffed to responsibly meet the demand. As the bureaus have experienced growing demand, they have increasingly relyed on the Data Center to discharge this responsibility on their behalf and thus have been able to avoid augmentation of their own limited, special-purpose reproduction laboratories.

A unique sub-set of the above is the new National High Altitude Aerial Photography program. The USGS is the coordinator of a nine-agency cooperative effort to acquire uniform mapping and resource photographic coverage of the conterminous forty-eight states. A key to the ultimate success of this program is the Data Center's ability to provide timely delivery of products to the participating agencies. Reliance on the Data Center as a central repository for Department of Interior acquired aerial photography will continue to accelerate in the out-years and the demand for reproduction products will continue to grow.

Prior to the early 1970's only two of the larger collections of aerial photography in the Federal Government were properly indexed and effectively available for use by other agencies or the private sector. The lack of complete information on the existence of the photography often led to duplicate acquisition programs by several agencies; in other cases photography was simply not used on a project because it was not known to exist.

The National Cartographic Information Center and the EROS Data Center were both inaugurated within the USGS in the early 70's. The NCIC was chartered with the responsibility of improving access to cartographic data available within the federal structure. The NCIC relyed on EDC, as a partner in this effort, to create and maintain a data base for indexing existing imagery. In operation for over eight years, this computerized system allows instantaneous and exact answers to questions of geographic coverage and characteristics of available imagery data. 4,865,000 frames

of aircraft data are addressed through the system. In addition to data acquired by the Department of Interior several other large collections have been indexed into the system, most notably the NASA Research Aircraft Images, acquisitions by the Environmental Protection Agency and some domestic mapping projects acquired by the Department of Defense.

Timely, accurate answers provided by this system have allowed users in the private and public sectors to maximize the use of the available images and avoid the cost of needlessly re-flying areas where adequate coverage exists. To continue to be effective, this system must be regularly updated with the new data acquired by, or of interest to, the Department of the Interior.

APPENDIX A

EROS DATA CENTER ACTIVITIES

CURRENT AND FUTURE

(The following additional information is provided for Question 1.)

A. Applications Research and Development

Applications Research

As the EROS Data Center transitions to a DOI user facility one of its principal responsibilities will be to conduct research required to achieve successful, operational applications of remotely sensed data. The emphasis of this research will be to support the resource information requirements of the DOI and its cooperators.

Improving remote sensing technology will provide new types of data products during the next decade, which will be both quite different and more useful to the DOI resource specialist or land manager than those data products available

today. The trend within the DOI during the next decade will be to more automated capabilities, and hence the EROS Data Center's applications research program will be directed toward that end.

Further, there will be an increasing need for data that can be used more easily as input to predictive or managerial models. Specific examples of applications research to be carried out include:

Wetland Mapping

Development of wetland mapping and classification techniques in support of the U.S. Fish and Wildlife Service National Wetland Inventory (NWI).

Geologic Mapping and Hazard Assessment

Development of texture feature extraction techniques for lineament mapping/drainage detection and interpretation in support of the Geologic Survey, Office of Surface Mining, and Bureau of Mines geologic mapping and hazard assessment programs.

Monitoring Irrigated Lands

Development of techniques for monitoring irrigation development useful to consumptive use models currently employed, or being developed, by the Geological Survey, Water and Power Resources Services, and Bureau of Indian Affairs.

Mapping Vegetation

Development of techniques for mapping and classifying vegetation/soil resources in support of the Bureau of Land Management Soil Vegetation Inventory Methods (SVIM) Program and the U.S. Fish and Wildlife Service Habitat Evaluation Program (HEP).

Image Processing and Analysis Technique Research

As a major DOI user facility, the EROS Data Center will develop new advancements in digital image processing and analysis technology. In order to be responsive to DOI informational needs, EDC will develop, and implement advanced hardware/software capabilities which facilitate atmospheric corrections, geometric corrections, classification enhancement, temporal data analysis, statistical analysis, ground data correlation, and multi-sensor data correlation and analysis.

Strategies for effective application within the DOI of remotely sensed data from a variety of sensor systems must be investigated and documented before the bureaus and offices of the DOI become operational in use of remote sensing technology. Image processing and analysis techniques will be developed for Heat Capacity Mapper Mission (HCMM), Seasat Synthetic Aperature Radar (SAR), and NOAA-5 data. Future Multi-linear Array (MLA), Stereoscopic Satellite (Stereosat), Magnetic Satellite (Magsat), Gravity Satellite (Gravsat), Fraunhofer Line Discriminator (FLD), Induced (Laser) Fluorescence, Shuttle Imaging Radar (SIR-A -B), Shuttle Large Format Camera (LFC), HCMM follow-on (Thermosat), Advanced Geological Satellite, and other proposed orbital systems will produce Earth resources data requiring processing and analysis technique

development. Proposed aircraft systems include Narrow Band Spectrometer (500 bands); Multispectral Thermal Sensor; active/passive scanner; Heat Capacity Radiometer (HCMR) and Multilook, Multispectral, Multisquint Radar. In addition, there is the continued need for EDC to investigate the practical utility of the more conventional sensor systems used in conjunction with data acquired by satellites. Specific examples of image processing and analysis technique research and development to be carried out include:

Area Selectability of Data

Development of techniques for pinpointing image corner coordinates and feathering mosaic borders to allow DOI users to select area specific data sets, rather than be constrained to geographic characteristics imposed by the sensor system collecting the data.

Image Enhancement

Development of improved techniques for correcting and enhancing satellite remotely sensed data in its digital form via the use of high-speed digital image processing and film generation systems.

Geometric Registration of Disparate Data Sources

Development of image processing techniques, using computer systems, which provide the flexibility to select common control information, resample to specific map projections, and produce high quality products of spatially correlated data sets.

Format Flexibility

Development of techniques to allow DOI users to select an image product format which is most cost effective for his/her operational use.

Georeferenced Data Base Development

Development of suitable digital georeferenced data information systems which accept remotely sensed data (as well as other forms of digital data) and are compatible with systems currently used or being developed by the bureaus and offices of the Department of Interior in their respective resource inventory, assessment and management programs.

Data Merging

Development of techniques for merging remotely sensed, geophysical, topographic, and other forms of digital georeferenced data to improve interpretation results and/or to input to resource information predictive models.

Statistical Modeling

Development of optimized statistical methods for mensuration and sampling by combining, in the most efficient manner, information extracted from remotely sensed data and collected in the field.

Development of Remote Image Processing Stations

The use of digital image data by the bureaus and agencies of the DOI for resource planning and management has increased significantly in the past five years. However, the high capital costs (approximately $500,000) associated with creating an image processing facility has inhibited the speed with which digital image data is accepted and used. Recent improvements in micro-processor technology will provide a solution to this problem.

Image display systems interfaced with micro-processors can be used to do a considerable amount of digital data manipulation. EDC has embarked on a major developmental project to design, develop, and test a low-cost prototype Remote Image Analysis Station (RIPS) that is based upon current and future image processing and analysis needs of the DOI. Personnel in regional, district, and local offices will have access to digital image analysis techniques through a low-cost remote terminal with image display and specific data processing capabilities. The eventual success of the remote image analysis station will be its flexibility to satisfy a broad spectrum of DOI resource informational requirements and yet be relatively low-cost (approximately $20,000) so bureau and agency offices can afford to procure multiple stations.

A RIPS unit is being designed and built at EDC that will allow demonstration and test of compressing and transmitting data to bureau and agency field offices and displaying, processing, and analyzing the data at the field office.

In addition, the role of a "host" computer at EDC will be defined, developed, demonstrated and tested. Among the tasks of the EDC "host" computer to a network of RIPS units are: (a) providing area-selectable image data sets, (b) performing pre-processing functions to the data sets (i.e., atmospheric corrections, geometric corrections, mosaicking, etc.), (c) and performing numerical analyses on large data sets.

Cooperative Demonstration Projects

Cooperative demonstration projects provide an opportunity for interested DOI agencies to test the operational utility of remote sensing techniques within their own organization. As Earth resource inventory, assessment, and monitoring techniques become more cost-effective and as more DOI personnel become trained in applying these remote sensing techniques, demand for cooperative demonstration projects at EDC (principally with BLM, USF&WS, USGS/WRD and NPS) continues to increase. Consequently, more projects are being performed, over larger geographic areas, with increased levels of complexity, which produce useful information for management decisionmaking. As a DOI support facility, EDC will meet this demand by continuing cooperative projects of national importance where satellite and/or aircraft remote sensing technology and multidisciplinary expertise are required to meet DOI information needs.

DOI cooperators are required to participate in all phases of the project, including planning, data analysis, field data collection, and reduction and synthesis of results. Emphasis is on utilizing and documenting proven remote sensing techniques and integrating these techniques into the bureau's operational mission.

B. Training and Technical Assistance

Training Workshops and Courses

As the EROS Data Center transitions to a DOI support facility, an important part of its responsibilities will be to continue an aggressive program of workshops and short courses for DOI users interested in remote sensing technology. Approximately 25 courses will be offered each year at EDC in which the subject matter of each course will be directed at meeting the informational requirements of a DOI bureau or agency. EDC will continue to cooperate with the USGS's Office of International Geology and will offer specialized training to foreign scientists. Furthermore, EDC will continue to encourage universities, through contracts and grants, to integrate remote sensing instruction into their Earth sciences curricula and to offer courses through their extension programs to practicing DOI professionals.

EDC has trained and experienced interdisciplinary instructors, excellent classroom facilities and advanced data analysis capabilities required to meet this demand. Training in the future, will shift from the fundamentals of data analysis and interpretation to more advanced training on topics of particular interest to DOI--such as geobased information systems, use of Earth science models, sampling/inventory procedures, and remote image processing system technology.

Resident Scientist Program

During and after the transition period, EDC will offer DOI scientists and engineers opportunities to work full-time at EDC for specified periods on remote sensing research projects of mutual interest to the resident's sponsoring organization and EDC.

While working toward the dual objectives of project completion and publications of results, EDC resident scientists will have access to the Center's data processing and analysis systems. EDC will benefit from this program in that (a) the diversified experiences and expertise of qualified scientists outside of the EDC will be applied to research problems of direct interest to DOI and (b) resident scientists will participate in EDC training workshops and cooperative demonstration projects designed to meet DOI informational requirements.

Regional Field Offices

As demonstrated by the EROS Field Office in Anchorage, Alaska, regional offices strategically located can provide easy access for DOI land managers and resource specialists to training opportunities and technical assistance in the applications of remotely sensed data.

The Field Office in Anchorage, which opened in March 1980, is conducting 6-8 training workshops annually and currently is engaged in several major DOI cooperative demonstration projects (vegetation mapping and caribou habitat assessment with the BLM and terrain analysis on the Wrangells-St. Elais

National Monument with the NPS). In addition DOI personnel and their cooperators are analyzing digital image data, using the Field Office's computer facilities, in support of their operational projects.

The field office relies heavily upon EDC for scientific and technical support, training aids, library services, and administrative services. Results of applications research and image processing/analysis technique development conducted at EDC are transferred to the field office. The principal activities of the field office include training, day-to-day technical assistance, demonstrations, and data analysis support for DOI personnel. The computer facilities provide "host" support for remote image processing stations located at DOI offices throughout the region.

Bureau Representation

The development of new applications of remotely sensed data as related to DOI bureau and agency programs and projects can best be accomplished through the direct use of EDC equipment and facilities by DOI personnel. Thus, EDC will continue to encourage divisions of the USGS and other DOI bureaus and agencies to assign personnel to the Data Center who are qualified in the field of remote sensing. Their duties will include: (a) serve as a liaison between interests and activities of the bureau and EDC, (b) provide an input of remote sensing data and methodology into ongoing bureau studies, (c) investigate new applications of remote sensing to bureau programs, (d) establish feasibility or operational capability of new remote sensing methods and procedures, (e) serve as consultant on remote sensing to bureau projects, and (f) provide training in remote sensing to bureau personnel.

In addition, non-resident bureau and office representatives will be designated to serve on the Center "Board of Directors" to: (a) coordinate bureau or office information needs and requirements for remotely sensed data, (b) strengthen the perception of remote sensing technology within the bureau or office, (c) serve as the remote sensing spokesperson for the bureau or office, and (d) provide a major voice in Center policy making.

Analytical Services

The acceptance of satellite remote sensing technology will significantly mature in the 1980's. Within the DOI, there will be an increasing number of remote sensing specialists, more training opportunities for new personnel, additional in-house image analysis facilities, and more frequent operational use made of various types of remotely sensed data. Many offices within the bureaus and agencies of the DOI will seek data analysis services from EDC as the Data Center evolves into a DOI support facility.

The Data Center has a multidisciplinary staff of remote sensing specialists and unique image processing/analysis facilities and capabilities, plus the flexibility afforded by a contractor work force, available to support DOI requests for data analysis services. An increasing demand within the DOI for several types of analytical services is anticipated. These services will include (a) digitizing of line maps into computer compatible data files, (b) development of geo-referenced multiple data sets properly formatted for input to existing DOI information systems, (c) performing specific Earth science applications inventory or assessment projects, and (d) providing "host" computer support to a network of remote image processing stations.

Bureau Project Implementation

Successful participation by DOI land managers and resource specialists in EDC training courses and cooperative demonstration projects contributes to operational project implementation within DOI bureaus and agencies.

A prime objective of EDC as it transitions to a DOI support facility will be to encourage operational project implementation within the DOI. Project work space, equipment and facilities, contractor work force and information services will be available at EDC to support DOI operational projects. Many near operational uses of remote sensing technology will become operational during the post 1984 time period.

C. Landsat Data Handling and Distribution

Since the launch of the first U.S. Civil Land Remote Sensing Satellite in July 1972, the EROS Data Center has developed and implemented systems and procedures for handling and processing satellite remote sensing data. During this period, the Data Center served as the principal U.S. facility for Landsat data archiving, product generation, and distribution to users, both domestic and foreign, and will continue this function until it is assumed by NOAA in the 1984 time period and the Data Center becomes a DOI Remote Sensing Science Center (planning reflected in the U.S. Transition Plan for Civil Operational Land Remote Sensing from Space dated June 1980).

At the time of this transition, the Data Center will physically archive approximately 1,750,000 frames of historical Landsat data; operate extensive systems for processing Landsat data and producing unique data

products for DOI users; have available manual and computerized systems for DOI users to access the EDC held Landsat data; annually receive either on high density digital tape or via domestic communications satellite between 5,000 to 10,000 scenes of current Landsat data which is needed by Interior users. In addition to the vast archive of historical and current Landsat data, satellite data from other programs (including the Heat Capacity Mapping Mission, Metsat, Mapsat, Seasat, Stereosat, the French Spot program, Japanese satellite program) will be available through the Center for Interior users thus providing a one-stop shop for a variety of satellite and aircraft remote sensing data.

Products for Interior Users

Techniques for merging satellite remote sensing, geophysical, topographic and other forms of digital georeferenced data to improve interpretation results and to input predictive models have recently been developed. Geometric correction algorithms are available for processing data sets as geographically registered data. This capability will allow processing of data according to a variety of menus, resulting in a spatially registered set of images which can be provided on either magnetic or film media. Once the data is geometrically corrected, a library of enhancement algorithms can be applied to improve image quality, filter radiance values, or perform radiometric adjustments. Using these techniques a variety of input media can be corrected, reformatted, and enhanced to provide digital or film products specifically tailored to a DOI users particular needs. These products can then be used in the users' own environment, either by automatic or manual interpretation. To supplement this

data integration, information in hard copy form such as topographic, soils and geologic maps can be converted to digital line graphs via EDC digitizing systems. This capability will be offered as a service to DOI users.

The availability of complex scientific computer systems provides a unique test bed for analysis of requirements, systems design, algorithm development, system checkout and accuracy verification, thereby accelerating R&D activities in support of unique image products.

These R&D activities will result in the ability to offer a remote sensing data set with the following characteristics:

Area Selectability and Digital Mosaicking

The user of remote sensing data will not be constrained to scene geographic limitations imposed by the system collecting the data. Rather, a geographic area can be defined of the area of interest. Where multiple scenes of data are involved, techniques for radiometrically feathering image border areas are being developed for production of high-quality digital or photographic mosaics.

Geographically Registered Data

Each picture element of each data type will be registered with corresponding pixels of all other data types, and to ground information, allowing selected data types to be easily overlaid. This registered data set will be provided in a variety of formats, allowing user selection of the format most cost effective for use in his application.

Processing and Format Flexibility

A variety of processing algorithms can be selected to tailor the product to user-specified map projections, allow conversion from one map projection to another, and to perform enhancements in support of particular disciplinary requirements. In addition, processing can be performed to extract from these data sets specific resource management information.

Information Packaging and Transmission

Consistent with the implementation of improved systems for handling, processing, and analyzing (thematic information extraction) remote sensing data, the Data Center is developing optimized data/information packaging techniques for use with the most advanced means of getting the data/information to an end DOI user consistent with his particular needs. High and low density digital data can be transmitted via domestic communications satellite or land line if needed in a timely manner. Also, data compression techniques are being developed that will allow efficient, cost effective transfer of image data and extracted resource information to and from analysis systems located at the EROS Data Center. Thus many DOI users in the field equipped with the low cost Remote Image Processing System that is being developed by the Data Center can interact with the large, sophisticated host system and receive only the resource information they need.

D. Aircraft Data Handling and Distribution

3,361,000 frames of mapping and resource aerial photography acquired by agencies of the Department of Interior currently reside at the EROS Data Center. These photographs have been acquired by the USGS, BIA, BLM, WPRS and others in the discharge of their agency responsibilities. New photography is being acquired at a rate of approximately 200,000 frames per year. Federal agencies within and without the Department of Interior use reproductions of these photos, often eliminating the need to acquire new photographic coverage.

The public has traditionally had access to reproductions of the photography acquired by the USGS. The Freedom of Information Act now mandates public access to all of the aerial photography acquired by the Department. Increasing awareness of the availability of these images is coupled with an increasing demand for reproductions from the public and private sectors.

No other laboratories in any of the bureaus are adequately equipped and staffed to responsibly meet the demand. As the bureaus have experienced growing demand, they have increasingly relyed on the Data Center to discharge this responsibility on their behalf and thus have been able to avoid augmentation of their own limited, special-purpose reproduction laboratories.

A unique sub-set of the above is the new National High Altitude Aerial Photography program. The USGS is the coordinator of a nine-agency cooperative effort to acquire uniform mapping and resource photographic coverage of the conterminous forty-eight states. A key to the ultimate success of this program is the Data Center's ability to provide timely delivery of products to the participating agencies. Reliance on the Data Center as a central repository for Department of Interior acquired aerial photography will continue to accelerate in the out-years and the demand for reproduction products will continue to grow.

Centralized Information System

Prior to the early 1970's only two of the larger collections of aerial photography in the Federal Government were properly indexed and effectively available for use by other agencies or the private sector. The lack of complete information on the existence of the photography often led to duplicate acquisition programs by several agencies; in other cases photography was simply not used on a project because it was not known to exist.

The National Cartographic Information Center and the EROS Data Center were both inaugurated within the USGS in the early 70's. The NCIC was chartered with the responsibility of improving access to cartographic data available within the federal structure. The NCIC relyed on EDC, as a partner in this effort, to create and maintain a data base for indexing existing imagery. In operation for over eight years, this computerized system allows instantaneous and exact answers to questions of geographic coverage and characteristics of

available imagery data. 4,865,000 frames of aircraft data are addressed through the system. In addition to data acquired by the Department of Interior several other large collections have been indexed into the system, most notably the NASA Research Aircraft Images, acquisitions by the Environmental Protection
Agency and some domestic mapping projects acquired by the Department of Defense.

Timely, accurate answers provided by this system have allowed users in the private and public sectors to maximize the use of the available images and avoid the cost of needlessly re-flying areas where adequate coverage exists. To continue to be effective, this system must be regularly updated with the new data acquired by, or of interest to, the Department of the Interior.

E. Fixed Facility Operations

Included here are those activities associated with facility operations which are relatively fixed in size and expense and will continue throughout the transition period. Examples are building lease/purchase expense, taxes, computer lease, utilities, security services, etc.